
**NOAA Technical Memorandum NMFS-F/NEC-91**

# The Large Marine Ecosystem (LME) Concept and Its Application to Regional Marine Resource Management

*1-6 October 1990, Monaco: Conference Summary and Recommendations*

**U. S. DEPARTMENT OF COMMERCE**
**National Oceanic and Atmospheric Administration**
**National Marine Fisheries Service**
**Northeast Region**
**Northeast Fisheries Science Center**
**Woods Hole, Massachusetts**

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Abstract: The overall objective of the Conference was to introduce the 'large marine ecosystem (LME) research and management approach' to a broadly representative group of scientists, managers, and administrators concerned with the sustainable use of marine resources. With regard to the application of the LME approach to principal driving forces affecting resource yields, the Conference was fortunate to have had expert and comprehensive presentations on several important LMEs of the Atlantic, Pacific, and Indian Oceans including the: Adriatic Sea Ecosystem. In addition, comparative analyses on the effects of basinwide physical and biological parameters influencing biomass yields were presented on the Barents Sea, Norwegian Sea, and West Greenland Sea Ecosystems.

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# The Large Marine Ecosystem (LME) Concept and Its Application to Regional Marine Resource Management

## *1-6 October 1990, Monaco: Conference Summary and Recommendations*

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**Woods Hole, Massachusetts**

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# PREFACE

The International Conference on the Large Marine Ecosystem (LME) Concept and Its Application to Regional Marine Resource Management was held during 1-6 October 1990 in Monaco. The conference was convened by the U.S. Department of Commerce's National Oceanic and Atmospheric Administration, The World Conservation Union, U.N. Intergovernmental Oceanographic Commission, and International Commission for the Scientific Exploration of the Mediterranean Sea. It was sponsored by the United Nations Environment Program, The World Bank, American Association for the Advancement of Science, Council for Ocean Law, National Science Foundation, U.N. Food and Agriculture Organization, International Coastal & Oceans Organization, Marine Mammal Commission, and Scientific Committee on Oceanic Research.

Patron of the conference was H.S.H. The Prince Rainier III of Monaco. It was hosted by the Musee Oceanographique de Monaco and The Principality of Monaco.

# CONFERENCE SUMMARY AND RECOMMENDATIONS

## SUMMARY

### Plenary and Case Studies

The three opening-session speakers, H.S.H. The Prince Rainier III of Monaco, Dr. Martin Holdgate, the Director General of The World Conservation Union (IUCN), and Dr. John Knauss, the Under Secretary for Oceans and Atmosphere of the United States Department of Commerce, provided the conference with guidance and encouragement to move forward with research, monitoring, and management programs fashioned around the marine ecosystem concept. The deliberations over the six days of the conference brought the participants closer to achieving that goal.

The overall objective of the Conference was to introduce the "large marine ecosystem (LME) research and management approach" to a broadly representative group of scientists, managers, and administrators concerned with the sustainable use of marine resources. This was accomplished with the cooperation of the 140 participants representing scientists, managers, and administrators from 37 countries. With regard to the application of the LME approach to principal driving forces affecting resource yields, the Conference was fortunate to have had expert and comprehensive presentations on several important LMEs of the Atlantic, Pacific, and Indian Oceans including the: Adriatic Sea Ecosystem (Dr. G. Bombace, Italy); Bay of Bengal Ecosystem (Dr. S.N. Dwivedi, India); Baltic Sea Ecosystem [Dr. G. Kullenberg, Intergovernmental Oceanographic Commission (IOC), Paris, France]; Canary Current Ecosystem (Dr. C. Bas, Las Palmas, Spain); Faeroe Plateau Ecosystem (Dr. V. Hansen, Denmark); Great Barrier Reef Ecosystem (Dr. G. Kelleher, Canberra, Australia); Gulf of California Ecosystem (Dr. L. Mee, Monaco); Gulf of Guinea Ecosystem (Drs. D. Binet and E. Marchal, France); Humboldt Current Ecosystem (Drs. J. Alheit, Germany, and P. Bernal, Chile); Sea of Okhotsk Ecosystem (Drs. V.V. Kuznetsov, V.P. Shuntov, and L.A. Borets, Union of Soviet Socialist Republics); and Yellow Sea Ecosystem (Dr. Q. Tang, Peoples Republic of China).

In addition, comparative analyses on the effects of basinwide physical and biological parameters influencing biomass yields were presented on the Barents Sea, Norwegian Sea, and West Greenland Sea Ecosystems by Drs. Johan Blindheim and Hein Skjoldal of the Institute of Marine Research, Bergen, Norway, and of the Benguela Current, California Current, and Patagonian Shelf Ecosystems by Dr. Andrew Bakun of the National Oceanic and Atmospheric Administration (NOAA).

### Mitigation Actions

The feasibility was demonstrated for introducing mitigating actions in an effort to increase the sustainability of usable biomass production of LMEs. In the Yellow Sea, where the government of the Peoples Republic of China first introduced juvenile shrimp for growout purposes in 1984, fishermen now harvest catches of 10,000 metric tons a year, based on the premise that the reduction of the natural predator field of demersal fish stocks provided an opportunity for the introduction of a higher-economic-yield shrimp resource as reported by Dr. Qisheng Tang of the Huanghai Sea Fisheries Research Institution, Qingdao, Peoples Republic of China ("The Effects of Long-term Physical and Biological Perturbations of the Contemporary Biomass Yields of the Yellow Sea Ecosystem"). A second example was the experimental introduction of artificial reefs or substrates for incorporating superfluous primary production to enhance biomass yields of benthic mollusks, fishes, and crustaceans in the Adriatic Sea Ecosystem presented by Dr. Giovani Bombace of the Institute of Marine Fisheries Research, Ancona, Italy ("Long-term Variability in the Food Chains, Biomass Yields, and Oceanography of the Adriatic Sea Ecosystem").

With regard to pollution studies, the importance of controlling the point sources of pollution in the river systems and wetlands of the coastal margins of LMEs was emphasized by Dr. Gunnar Kullenberg of the IOC, Paris, France ("The Baltic Sea as a Pollution-driven LME"), Dr. Francois Doumenge of the Oceanographic Museum, Monaco ("Enclosed/Semi-enclosed Seas: A Status Report"), and Dr. Alasdair McIntyre of Aberdeen, Scotland ("Application of LME Management for Pollution-driven Systems"); the lack of significant contamination of the offshore, more open waters of LMEs was noted. The example of successful mitigation of the biomagnification of large-scale contamination from heavy metals and organochlorines in the Baltic was a particularly encouraging example of how scientists, administrators, and managers of several nations can work together to carry forward positive management actions for an entire LME.

### Driving Forces

The impacts of ocean physics on pelagic stock yields and of overfishing on demersal stock yields were considered as important driving forces in the Sea of Okhotsk ecosystem by Dr. Vladimir Kusnetsov of the All-Union Scientific Research Institute of Marine Fisheries and Oceanography in Moscow, and his colleagues V. Shuntov and L. Borets of the Pacific Research Institute of Marine Fisheries and Oceanography in Vladivostock, Union of Soviet Socialist Republics. The importance of ocean physics as the principal force driving variability in biomass yields of the Humboldt Current Ecosystem was stressed by Dr. Jurgen Alheit of POLARMAR in Bremerhaven, Germany, and Patricio Bernal of the Institute for Fisheries Studies in Santiago, Chile.

Similarly, changes in velocity and direction of the Equatorial Under-Current was the principal force driving variability in the yields of the pelagic fisheries of the Gulf of Guinea Ecosystem according to Drs. Denis Binet of the French Research Institute for Ocean Utilization in Nantes, France, and Emile Marchal of the Office of Overseas Scientific Research and Technology in Paris, France, and of the Canary Current Ecosystem as reported by Dr. Carlos Bas of the Spanish Institute of Oceanography in Las Palmas, Spain; in both LMEs, the effects of fishing in causing large-scale variability in the biomass yields were considered secondary.

In contrast, loss of habitat in the coastal zones around the Bay of Bengal Ecosystem has had a detrimental impact on the nursery grounds of shrimp, whereas the annual yields of the offshore fisheries of the ecosystem have been increasing from 1.9 million metric tons (mmt) in 1981 to 2.4 mmt in 1987, according to S.N. Dwivedi of the Department of Ocean Development in New Delhi, India. Dr. Dwivedi encouraged the participants to consider the convening of a symposium and workshops for marine scientists and students from India and other countries bordering on the Bay of Bengal to encourage further study of the sustainability of the entire Bay of Bengal Ecosystem under the growing stresses on the ecosystem being imposed by the large population of people living along its coastal margins.

From the case studies of LMEs, new useful insights were gained for management with regard to principal driving forces, and for the desirability of improved monitoring of the LMEs being driven by physics, such as the Humboldt Current Ecosystem and the Patagonian Shelf Ecosystem, not only from a fisheries yield perspective, but also with regard to early warning of the impacts of global warming (Dr. A. Bakun: "Physical and Biological Parameters Influencing the Biomass Yields of the Benguela Current, California Current, and Patagonian Shelf Ecosystems").

## Theoretical Legal and Practical Considerations

From the theoretical presentations on LMEs, it was apparent that the problems of scale and variability need to be addressed to improve understanding of processes within an LME. The theoretical experts, Dr. Simon Levin of Cornell University ("Models for Forecasting Biomass Yields in LMEs"), Dr. John Beddington of the University of London ("Ecological Theory and Alternate Stable States in Large Marine Ecosystems"), and Dr. Brian Rothschild of the University of Maryland ("Biodynamic Theory and LMEs"), stressed the importance of recognizing that more effort is required in understanding the relationships among scales and levels of biological and physical organization within LMEs. In a summary statement, Dr. Levin stressed that populations do not exist in isolation. Examination of the effects of pollutants on harvesting and of other stresses is properly placed within the context of the regional ecosystem which governs the dynamics of its component populations, mediates the fate and transport of materials, and is the most nearly inclusive system feasible for investigating biophysical interaction.

For these reasons, the LME approach, including the study of variability, represents a sensible model for ocean management. In this regard, Dr. Martin Belsky of the Albany Law School argued that the U.N. Law of the Sea can be interpreted as mandating an ecosystem approach to resource and environmental management ("Legal Regimes for Management of LMEs and Their Component Resources"), and Tucker Scully of the U.S. State Department provided the conference with an example of the ecosystem approach to the management of living marine resources in the Antarctic, supported by a 21-country commission and an active scientific committee ("The Convention on the Conservation of Antarctic Marine Living Resources--A Model for Ecosystem Management"). Dr. Arthur Dahl of the United Nations Environment Program indicated to the conference that the LME concept is compatible with the U.N. regional seas approach to ocean research and management ("The LME Approach to Regional Seas Action Plans and Conventions: A Geographic Perspective").

## International Science and Management

The evolution of the LME concept and its applicability to scientific and management issues involving fisheries, coastal zone, pollution, and global warming was reported by Dr. Gotthilf Hempel of the Alfred Wegener Polar Research Institute in Bremerhaven, Germany ("Purpose and Organization of LME Conference from a Scientific Perspective"). Dr. Michael Reeve of the National Science Foundation (NSF) suggested means for incorporating process-oriented studies of ocean processes within the framework of LMEs, particularly with regard to the Global Ecosystems Dynamics Program of NSF ("Application of International Global Change Research Programs to Long-term LME Management"). The application of the LME approach to the research of the Faeroe-Plateau Ecosystem was reported by Dr. K. Vagn Hansen of the Danish Institute for Fisheries and Marine Research, with special emphasis on the large-scale gyre system around the periphery of the ecosystem serving as a boundary feature for plankton and the pelagic stages of the benthic communities. Progress in applying an ecological approach to research and management of the Gulf of California Ecosystem was given by Dr. Laurence Mee of the International Atomic Energy Agency in Monaco.

The steps to be taken to integrate LME scientific studies into the management of ocean resources and ocean space were addressed by Professors Robert Knecht and Biliana Cicin-Sain of the University of Delaware ("The Utility of the LME Concept to Ocean Management"), and a very well designed plan for the research and management of the Northern California Current System LME was put forth by Dr. Daniel Bottom of the Oregon Department of Fish and Wildlife ("Research and Management in the Northern Cali-

fornia Current Ecosystem"). With regard to management of LMEs, Dr. Niels Daan of the Institute for Fishery Investigations, Ijmuiden, The Netherlands, reported on the need for an integrated management approach to LMEs in general, and the North Sea Ecosystem in particular. His recent modeling of the effects of closing areas of the North Sea to fishing effort to enhance fish stock production showed that closed areas had little effect in enhancing fisheries production ("A Simulation Study of Effects of Closed Areas to All Fishing with Particular Reference to the North Sea Ecosystem"). Dr. Graeme Kelleher emphasized the utility of a holistic approach to the management of entire LMEs in his excellent presentation on "Sustainable Development of the Great Barrier Reef as a Large Marine Ecosystem."

## New Technology

The way forward in LME studies will be made more rapidly with the application of new technology now available in hydroacoustics to deal with the difficult problem of sampling the zooplankton component of LMEs as described by Dr. Van Holliday of TRACOR Corp. in San Diego, California ("Applications of Advanced Acoustic Technology in LME Studies").

The combination of new molecular biological techniques for species and stock identification along with available laboratory robotics systems should allow for more efficient biological sampling designs and processing of samples at sea and in the laboratory as outlined by Dr. Dennis Powers of Stanford University ("Application of Molecular and Biotechnological Methods to Large Marine Ecosystem Studies"). On the larger scale, it was clear from the presentation by Dr. James Yoder of the University of Rhode Island that ocean features and processes can be studied from a combination of satellites and surveys using color scanning and other photo-optical sensors for measuring productivity, standing stock, and flux at the LME scale for the oceans of the world ("Application of Satellite Remote Sensing and Optical Buoys/Moorings to LME Studies").

## Regional Approach to LMEs

With regard to the regional approaches to LMEs, we were given the benefit of a comparison of LMEs around the Pacific Rim, with emphasis on a comparison of two different LMEs -- the Sea of Japan and the Humboldt Current -- by Dr. Joseph Morgan of the East-West Center, University of Hawaii ("Large Marine Ecosystems of the Pacific Rim"), followed by a discussion of the role of political factors in the management of the Canary Current, Gulf of Guinea, and Benguela Current Ecosystems by Dr. Victor Prescott of the University of Melbourne, Australia, who has suggested several follow-on actions ("The Role of National Political Factors in the Management of LMEs: Evidence from West Africa"). Professor Francois Doumenge of the Oceanographic Museum in Monaco provided a comprehensive description of the formation of natural regions of the Mediterranean, indicating that several of them, including the Adriatic Sea, constitute natural subsystems, ending with a cautionary comment that drew attention to the need for mitigation of river system developments that would generate negative impacts on the long-term sustainability of the Mediterranean. The importance of human interventions on the sustained biomass yields of the Mediterranean and Black Sea Ecosystems, based on changes in fisheries landings, were presented by John Caddy of the U.N. Food and Agriculture Organization (FAO) in Rome, Italy ("A Contrast between Recent Fishery Trends and Evidence for Nutrient Enrichment in Two Large Marine Ecosystems: The Mediterranean and the Black Sea"). The session concluded with a summary of the biology and physics of the Gulf of California Ecosystem by Dr. Laurence Mee.

Important areas for further consideration in the development and application of the LME concept, including the clarification of the number and extent of LMEs on a global basis, were noted by Dr. Lewis Alexander of the University of Rhode Island ("The Regional Approaches to LMEs").

# RECOMMENDATIONS

## Sustainable Development

The conference participants agreed that there are possibilities for applying the LME concept as a useful means for addressing the many-faceted problem of sustainable development of the world's oceans. The concept provides a framework for research, monitoring, and modeling of ocean space that will be of significant aid in focusing marine research and management aimed at sustaining biomass yields, and at reducing and eliminating pollution, coastal zone degradation, and wetlands losses around the terrestial margins of LMEs on a global basis.

In exploring the means of pursuing the LME approach, participants were mindful of the ongoing activities of existing international organizations as well as dispersed responsibilities within national governments. At the same time, it was realized that a systemic and comprehensive approach can only succeed if a means is found to bridge such institutional separations.

## LME Committee

The conference agreed that a mechanism which could assist in building these bridges would be an International *ad hoc* Large Marine Ecosystem Committee. Such a committee could be formed under the auspices of IOC, FAO, UNEP, and IUCN. It would consist of leading experts in the LME

approach, science managers, representatives from donor organizations, ocean and coastal managers, and expertise in the global and regional legal regimes and organizations relevant to managing ocean uses.

## Terms of Reference

The committee would pursue the potential of the LME concept by: (1) further identification and definition of the earth's LMEs; and (2) increased understanding of the application of the LME concept to the management of marine resources from an ecosystems perspective.

The committee would carry out its functions in a number of ways, including the establishment, as soon as possible, of a working group of scientists to explore ways of using the LME concept as a means to identify research, monitoring, and modeling needs. The committee would also establish a second working group, consisting of ocean and coastal managers, to explore ways of applying the LME approach to a range of management problems through development of various strategies for coordination by coastal countries, fisheries commissions, and other relevant management bodies. A third working group might be established in the future to focus on synthesis and transfer of LME information to decisionmakers.

## Priority Actions

Some concrete steps to be undertaken by the Committee based on deliberations of the IUCN, IOC, and UNEP workshops and the discussion groups are to:

- Produce a map of the distribution of LMEs. Such a map would be sent to regional experts for review and comment.
- Select a few suitable LMEs for pilot programs.
- Convene workshops with representatives (scientists and managers) of the selected LMEs. The objectives of such workshops would be to: agree on prioritized needs for pertinent data; demonstrate the use of modeling; find partners (international agencies, donor institutions, research institutes) in the developed countries which would assist in regional studies; identify training needs; and develop a plan for collecting available data as a basis for regional workshops.
- Convene regional workshops (one year after first workshop) for the purpose of identifying key processes to be studied (based on the data made available over the previous 12 months), developing plans for integrated ecosystem studies on regional and national levels, and organizing these studies.
- Follow up with activities, including workshops, which would analyze new data bases as they became available.
- Establish a training package for research and ecosystem management for national use within EEZs and in regions where LMEs include multiple jurisdictions.
- Convene periodically (3-6 years) international conferences to report on the state of the world's LMEs.
- Report back to sponsoring organizations.
- Contribute to the deliberations of the U.N. Conference on Environment and Development in 1992.

## Comparative Studies

It was pointed out that comparative studies of similar ecosystems (for example, the North Sea/Yellow Sea, the Baltic Sea/Black Sea/Adriatic Sea/Bay of Bengal, *etc.*) is one method for advancing the LME concept. This approach could be an aspect of the regional workshops outlined above. It would have the advantage of improving understanding of similar systems, as well as promoting the most relevant cooperative efforts between developed and developing countries.

## Ecosystem Stress

It was also pointed out that in addition to the need for research coordination for LMEs and their biological components or subsystems, there is a need for immediate management action to arrest or reverse ecosystem degradation and stress due to human action. For some systems, indications already exist as to the kinds of inputs that led to degradation of these systems, as well as the type of action that would be needed to begin to reverse deleterious changes and their negative economic consequences. In this connection, the active efforts of Baltic coastal states to reverse contamination of the LME were viewed with keen appreciation by conference participants. In other cases, it is clear that open exchange of information between the parties concerned is needed, with a view to developing a concerted plan of action. In this category of affected LMEs are included subcomponents of LMEs such as degraded intertidal areas and wetlands, estuarine and anadromous fauna and coastal wetlands, which form important parts, especially of tropical and subtropical LMEs. The conference also noted the fragility of semi-enclosed seas as LMEs currently under stress. Of particular concern in the immediate future are the Mediterranean and Black Sea systems, where indications suggest that the time for effective coordination in planning management actions may be very short.

The *ad hoc* committee would cease to exist when the relevant international institutions and participating scientists and managers are able to proceed with the tasks without it.

Monaco
6 October 1990

K. Sherman
T. Laughlin
D. Elder

# CONFERENCE ADDRESSES

## WELCOMING ADDRESS

***H.S.H. The Prince Rainier III of Monaco***

As President of the International Commission for the Scientific Exploration of the Mediterranean Sea, we are particularly happy that the Oceanographic Museum in the Principality of Monaco is hosting this international conference, the objective of which is to introduce the "large marine ecosystem" concept and its application to the management of living resources within the context of regional planning.

The immensity and the urgency of the problems facing our marine coastal states are highlighted by the joint efforts of The World Conservation Union, UNESCO's Intergovernmental Oceanographic Commission and the National Oceanic and Atmospheric Administration of the Department of Commerce of the United States of America.

The presence at this meeting of Dr. Martin Holdgate, Director General of The World Conservation Union, of Dr. Gunnar Kullenberg, Secretary General of UNESCO's Intergovernmental Oceanographic Commission, and of Dr. John Knauss, Under Secretary for Oceans and Atmosphere of the United States Department of Commerce, bears witness to the commitment of these institutions to a sustained effort to put forward foundations for a new international order which we feel must be built upon the conservation and restoration of the marine world's living resources.

The scientific and economic significance of this conference has drawn the support of several bodies, namely: the United Nations Environment Program, The World Bank, the American Association for the Advancement of Science, the Council for Ocean Law, the National Science Foundation, the international Food and Agriculture Organization, the International Coastal and Oceans Organization, the Marine Mammal Commission, and the Scientific Committee on the Oceanic Research, to which we have pleasure in extending our gratitude and our congratulations to each and to all on their discernment.

For its part, the International Commission for the Scientific Exploration of the Mediterranean Sea is most happy to have been responsible for the organization of this fifth conference which expresses converging concerns. We have no doubt that your discussions will encourage dialogue at the talks which are to take place in a few days' time at this institution's XXXII Plenary Assembly-Congress whose deliberations we will follow personally.

Let us not forget that the present conference is the product of an intense period of preparation led by Danny Elder, Coordinator of The World Conservation Union's Marine Program, Thomas L. Laughlin, Head of the International Liaison Office of the NOAA, and Kenneth Sherman, Director of the Narragansett Laboratory. We wish also to acknowledge the efforts of the Oceanographic Museum and the work of Professor Francois Doumenge and his colleagues to whom we extend particular thanks.

We are delighted to see eminent specialists from the world's most prestigious oceanographic centers gathered here for this international conference. Our only regret is the absence of Professor Takahisa Nemoto, Director of the Oceanographic Institute of the Imperial University of Tokyo, who so generously welcomed us aboard the research vessel *Hakuko Maru* when berthed in the principality last January, and who died suddenly a few weeks ago.

As sovereign of a state for which the maritime environment is vital, we are most particularly aware of the necessity to preserve the ocean's resources. By signing the "Ramoge" agreement with France and Italy, the Principality of Monaco has committed itself to a regional cooperation policy as early as year 1976.

Therefore, the Principality of Monaco has taken a leading role in keeping with the subsequent emergence of a management policy implicitly founded on the large marine ecosystem concept.

More than ever before, the spreading of industrial pollution, the disposal of urban waste at sea, the long range contamination of aerosols, as well as the global problem of overexploitation of fish resources which is threatening extinction of numerous species, demonstrate that all states are concerned and require a response from mankind as a whole.

Major disasters can be provoked by climatic, hydrological, or geological accident as well as by the overexploitation of fish resources or agricultural, urban, or industrial pollution. In the middle term, human activities are likely to disrupt the ocean/atmosphere relationships and affect the protective ozone layer as well as the partial pressure of carbon dioxide in air and water. Appropriate responses will only be found through an international cooperation and a multidisciplinary approach, namely in the disciplines of physics and biology, as well as economics and law. Hence, we have given the Principality of Monaco's support to the Council of Europe's Open Partial Agreement on the prevention of, protection against, and organization of relief in major natural and technological disasters.

In this respect, the Scientific Center of Monaco founded in 1960 has just undergone reorganization to comply with the demands of increased efficiency. The European Oceanographic Observatory created within the framework of this reorganization will contribute to the forecasting, prevention, and handling of major disasters affecting the marine life. Its research laboratories will develop appropriate methods and means to detect the risks and to speed up the restoration of disrupted environments.

Furthermore, the last conference dedicated to large marine ecosystems highlighted energy transfers and the relationships between different elements of the marine life.

Also emphasized was the urgent need to set up a model management system to avoid disastrous crises which jeopardize numerous communities over vast areas. The increased incidence of eutrophication which can affect entire seas -- the Adriatic in 1989 -- and high death tolls -- among seals in the Northwest Atlantic, great sharks, reptiles and marine mammals caught in nets drifting in the southern South Pacific, the northern Pacific, the Bay of Biscay, and, unfortunately, the Mediterranean -- underline the quite obvious global dimension of the dangers to which the ocean is exposed.

It is our fervent hope that scientists will work together to arouse a universal awareness of the risks incurred if states do not act quickly to set up multi- and supra-national systems to provide for the implementation of vital safeguards and conservation measures.

The Convention for the Conservation of Antarctic Marine Living Resources is, we feel, an example which should be followed, as are the concerted efforts in the USA at federal and state levels, including federal institutions such as the NOAA, to establish a framework of appropriate measures for the protection and the conservation of resources and the environment through a dynamic biogeographical approach in the context of large marine ecosystems.

We are happy that the organizers of this International Conference on the Large Marine Ecosystem Concept and Its Application to Regional Marine Resource Management have chosen the Principality of Monaco to hold this first meeting outside the USA in association with the International Commission for the Scientific Exploration of the Mediterranean Sea, founded by my noble ancestor Prince Albert I. Henceforth, the international law of the sea must seek its foundations in the results of scientific research.

In this spirit, we feel it is vital that highly qualified fora such as yours make the voice of wisdom and reason heard calling for widespread international dialogue to lay down standards protecting species and their habitats. The devastation which has long gone unpunished, wrought by a series of mining and fishing processes has already affected wide areas which were still unsullied 30 or 40 years ago. We will namely mention the African, American, and South East Asian intertropical zones as well as the subarctic seas of the Atlantic and the Pacific.

The southern part of the planet in its turn is being affected, with damage to Kerguelen shelf and plateau of Patagonia and Cape and especially the influences of drift-net fishing in the southern Pacific.

The time has come to react by proposing an alternative to corporate and national egoism. Our good wishes are therefore with you throughout your deliberations in the hope that they will rapidly lead to the international dialogue which alone can provide a solution for an anxious and expectant mankind.

## KEYNOTE ADDRESS

***Dr. John Knauss***
**Under Secretary for Oceans and Atmosphere**
**U.S. Department of Commerce**

I am pleased to be with you here today in this picturesque setting in Monaco, with its long and distinguished ocean tradition. It is most fitting that His Serene Highness Prince Rainier has graciously agreed to host this conference. The Grimaldi family was instrumental in supporting the great age of ocean discovery during the last century and the early part of this one. The tradition continues with support for the Ocean Science Center of Monaco, the International Hydrographic Bureau, the International Laboratory of Marine Radioactivity, and the world-famous Musee Oceanographique. Here in Monaco, where old traditions are facing new challenges, it is appropriate that this conference serve as a starting point for launching a new international effort to mitigate the effects of increasing stresses on ocean resources.

We are here to discuss large marine ecosystems, LMEs. My message is a very simple one. If you, the experts, conclude that this concept makes ecological sense, then I believe it is high time we get on with the business of monitoring large marine ecosystems with the goal of trying to understand how they work. We know LMEs are subject to large year-to-year and decade-to-decade variability. We know that much of this variability is independent of man-induced effects. One of the goals of LME programs must be to tell the difference between the variability that is "natural" and that which is anthropogenic.

These are exciting times to be an environmental scientist. Ready or not, we are in the midst of a major, worldwide ecological experiment. This planet is stressed by a population of five billion people, and I expect that stress is going to increase during the next century as the population heads toward 10, perhaps 15, billion people. Almost all of us share the goal of living better than our grandparents did. As a consequence, we are seeing loss of species, change in climate, change in our environment. One can make a good case that if present trends continue, we will be passing through a geological boundary. And we are responsible.

Like many of you, I have followed the debate of the past few years as to whether the Cretaceous-Tertiary boundary, the K-T boundary that did in the dinosaurs, was caused by

a giant meteorite, an outpouring of volcanoes, or some combination of both. To the best of my knowledge, no one has blamed that boundary on the dinosaurs.

We are probably the first species on this earth capable of causing a geological boundary. We are certainly the first species capable of recognizing what we are doing.

Even though we can see the effects of man almost everywhere in our environment, differentiating between and quantifying those changes in our environment caused by man and those resulting from natural variability is often not easy. Consider climate change, a subject that has captured the attention of the public and politicians, as well as scientists. The atmosphere of this earth has slowly warmed and cooled over time scales of decades and centuries. We are reasonably certain that a major key to variations on this time scale are a result of ocean-atmosphere interactions. We can show this is true in a statistical sense in our large computer-driven global climate models. If we let our models run for the equivalent of hundreds of years, they show the correct range and time scale of temperature fluctuations. No two years are alike. The temperature changes from year to year and decade to decade. But our models are not yet good enough that we can input this year's values and predict next year's climate.

Thus, the debate about global warming. There is little disagreement that a doubling of greenouse gases such as carbon dioxide and methane will affect our climate. All models suggest some warming of the atmosphere, but the positive and negative feedbacks associated with that perturbation are very complicated, and our models are very crude. One cannot be certain that the slight warming trend of the last century is natural or man-driven. The present debate is not about whether a doubling of greenhouse gases will cause some warming of the atmosphere but about how much and how soon.

As limited as our knowledge of atmospheric variability and the reasons for it is, our knowledge of ocean variability is even more rudimentary. Some of our best evidence is indirect. Most experts conclude that any variability in the atmospheric climate of more than a year must be accompanied by an analogous change in the ocean climate. To be more precise, the changes in the atmospheric climate are probably driven in large part by changes in the ocean. Unlike the atmosphere, where we have reasonably good records of temperature going back hundreds of years, our ocean records are very limited. We can simply infer changes in the ocean by noting the changes in the atmosphere. We do not know the amplitude and shape of the spectrum in the ocean, let alone the processes that determine it.

What about biological variability in the ocean? We continue to gather an increasing number of examples of biological fluctuations resulting from overfishing and from localized pollution, but well documented examples of natural variability are more rare. I expect the best are the high-frequency, year-to-year changes in the recruitment of commercial fish species. There can be orders of magnitude variation in yearly recruitment levels, which, in the absence of other pressures, lead to a relatively stable population of mature fish.

There is some evidence of low-frequency -- greater than 10-years -- fluctuations. Perhaps the best documented is the periodic dominance of first the sardine and then the anchovy populations off the west coast of California. Some have speculated that not all the recent spectacular crashes of commercial fisheries, such as the Alaskan king crab and the Peruvian anchovy, have been solely caused by overfishing. We suspect that the declines in these fisheries may have been helped along by natural environmental variability. We simply do not know enough about the processes involved, or the complexity of the interactions, to make meaningful predictions of trends. This we must do, if we are to manage our living marine resources wisely.

How does all of this apply to LMEs? Let me summarize. This planet is being stressed by a growing population and a growing standard of living. It is clear that there are fluctuations in the atmosphere and the ocean as well as in land and marine ecosystems that are independent of the influence of man. We have an increasing number of man-induced changes in our physical environment: the ozone hole in the stratosphere, smog and acid rain in the atmosphere, pollution in our estuaries, and eutrophication in some of our enclosed seas. It is often difficult, however, to separate the natural variation from that which is man-induced in many of our physical systems, particularly the oceans. In large part, I believe this is because our level of understanding is inadequate. With rare exceptions, the monitoring of physical, chemical, and biological parameters in LMEs is weak. Without exception, our understanding of how the systems work in any LME is weak. Perhaps it is time to do something about it.

I expect before the end of the century we will have the beginnings of an international ocean observing system, but that system will be designed to monitor large-scale ocean/atmosphere interactions. Its purpose will be climate prediction, and I expect the emphasis, at least in the beginning, will be centered on such areas as the tropical Pacific and Antarctica where these types of interactions are expected to be strongest. As contemplated, it is not a system keyed to LMEs. I expect an LME system would be more concerned with pollution and other man-induced change. I expect it would be more ecologically oriented.

If one set out to design a coastal ocean monitoring system, are LMEs the correct geographical unit? If they are, would it be useful to organize a set of regional programs, each designed for a specific LME? Such programs would have as a goal the monitoring of the system and understanding how the system works and how man is perturbing the system. Those responsible for the program of each LME could meet locally on a regular basis. Perhaps every few years they could come together internationally to compare notes and report on the health of the ocean.

This is a program that could be organized through one, or some combination of United Nations agencies, perhaps with advice from the International Council of Scientific

Unions, the ICSU. I believe the experience of ICSU's International Geosphere Biosphere Program, the IGBP, may be useful. Their objective is "to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth System, the unique environment it provides for life, the changes that are occurring in that system, and the manner by which these changes are influenced by human action."

Substituting "large marine ecosystem" for "total earth system" may provide a concise objective for a program of the type a number of you are interested in developing. Perhaps the development of such a program could be considered in Brazil in 1992 at the United Nations Conference on Environment and Development.

The long-term goal of such a program, or its ultimate goal, will be to understand how the system works well enough to predict its future state. That is what science is about. It will not be easy. The short-term goal, which I believe is an achievable goal, is no less important. It is to monitor the health of the ocean.

## OPENING ADDRESS: THE CONSERVATION OF LARGE MARINE ECOSYSTEMS

***Dr. Martin W. Holdgate***
**Director General**
**International Union for Conservation of Nature and Natural Resources,**
**The World Conservation Union**

Your Serene Highness, Your Highness, Professor Doumenge, ladies, and gentlemen. It is a great pleasure for me to be here in Monaco, on the territory of a state member of IUCN, and to have the opportunity of addressing this distinguished gathering.

I want to consider IUCN, The World Conservation Union's role in promoting conservation of the large marine ecosystems with which this symposium is concerned. I use the word "conservation," of course, in the usual sense -- the maintenance of the natural systems of the oceans, as an important component of planetary biological diversity and ecological function, and as an important resource for sustainable use by people.

A subsidiary thread to these remarks will concern the transferability of concepts of conservation and sustainable use, largely developed on land, into the oceans. This is a topic on which many of you are far more expert than I am, but I believe that it is possible to argue that concepts have from time to time been loosely transferred, and have led, as a result, to suboptimal formulation of policy goals and management practices.

For example, the word "development" can be defined reasonably precisely for terrestrial resources. I would describe it as the modification of the structure and functioning of environmental systems so that an increasing proportion of their productivity is provided in a form directly useful to humanity. For example, development may involve changing forests growing on fertile soil to farmlands capable of sustainable use, and producing food, fiber, or other useful products at an enhanced level. Development can also mean the controlled conversion of productive living resources into nonproductive built environments, and it is often used uncritically to refer to the expansion of the technosphere at the expense of the biosphere, regardless of long-term sustainability, although IUCN would hope such destructive development can be minimized.

I digress like this because I think one can contend that the oceans are not the scene of development in the sense that the term can be used on land. The transformation of marine ecosystems to yield an increasing quantity of a product, directly useful to humanity, has largely been a feature of coastal zones. Mariculture for algae, mollusks, crustaceans, and fish has been a growth industry in the last two decades, but accounts for only about five percent or less of global fishery landings. Much development affecting the marine environment has been in the form of the encroachment of the built environment on the natural, with engineering alterations of coastlines and the discharges of industrial wastes -- in neither case, conducive to the balance of sustainable productivity of marine ecosystems.

The fact is that over much of the ocean, sustainability has not been the determinant motivation in human-use patterns. As we are all aware, early fisheries treated their quarry as an "open-access resource" with a strong element of competition between the exploiters, and these two factors were directly responsible for the overconsumption, and consequent depletion, of such target organisms as whales, fur seals, and a number of stocks of food fishes. In 1982, it was estimated that world fishery landings were 15- to 20-percent less than they might have been had fishing effort and offtake been adjusted to the optimum productivity of the systems. Since then, there has been, if anything, an increase in the nonselective and destructive impact of fisheries, despite the regulatory effort. Industrial fishery and driftnetting are both threatening the balance of ecological systems, and tending, through their nonselectivity, to a great degree of waste through the blind catches of nontarget organisms that they are capturing and discarding.

The problems created by the "open-access approach" have been exacerbated by the fact that most offshore fisheries are managed as separate entities from the nearshore environments that provide the breeding sites and nursery areas of these "offshore" species. It is becoming more widely accepted that we can no longer ignore such interrelationships. Our management strategies must take account of the dependence of offshore fisheries on nearshore envi-

ronments, as well as the dependence of different components of the marine food web on each other.

In a similar way, over much of history the discharge of pollutants to the sea was regarded as the ideal disposal method because of the vastness of the oceans; the apparently large dilution that they provided; and the belief that by putting a waste into the sea, it was being removed from the immediate environment of humanity. Virtually no country in the world had, until recently, a considered policy to regulate its discharges to the oceans at a level well within the capacity of the marine system to disperse those wastes without threat to ecological balance, and without the accumulation of undesirable residues in living organisms. Very similarly, engineering changes on the coastline have normally been planned without much thought of their impacts on the ecology and productivity of the systems affected -- even though it has been known for decades among marine biologists that shallow and productive inshore waters, most at-risk from engineering development and pollution, were important nursery areas for species that later moved offshore and became the targets of commercial fisheries.

Of course, there have been attempts at a regulatory effort. A number of fisheries commissions, attempting to give guidance on optimal yields, were established in the early part of this century. However, being based on voluntary consent, they generally had no means of restricting catches to appropriate levels, and many states withdrew from the agreements. In the 1950s, the concept of regional fisheries commissions found favor once again, so that now they exist for most ocean basins and seas. The main value of these efforts has been a better monitoring of the state of stocks, and at least some recognition of the need for regulation of the fishery effort. In the Northeast Atlantic, both the information base and the controls have been relatively good, whereas in some other areas, like the North Pacific, only some species have been effectively managed.

The most recent regional fisheries convention, the Convention on the Conservation of Antarctic Marine Living Resources, CCAMLR, is unique in that for the first time, it incorporated in its provisions a requirement that the taking of krill and other target species should be regulated, not only so that there was no threat to the species concerned, but so that the overall balance of the ecosystem was sustained and the recovery of depleted species unimpaired.

Even so, there are questions as to whether CCAMLR will effectively regulate international effort on the high seas in Antarctic waters, any more than the other fisheries conventions have proved their capacity to adjust fishing to the optimal level, and thereby, provide maximal yields without ecological imbalance. It is commonly stated that the salvation of marine fisheries has, in fact, been the extension of national jurisdictions to 200 miles, thereby giving a single sovereign state at least the opportunity to regulate the use of resources within its limits. There is nothing surprising about this. On land too, the establishment of a unique economic interest in a resource, together with the powers to manage the use of that resource, has often been proved the soundest base for conservation and sustainability. It is a fact, perhaps a sad fact, of modern life that international instruments are generally less effective than national ones.

Marine pollution has also been a focus for international action. The London, Paris, and Oslo conventions of the early 1970s were established, first and foremost, because of international concern about the dumping of chemical wastes in the epicontinental seas. Regional conventions, spearheaded by UNEP's Regional Seas Office, now Ocean and Coastal Areas Program Activities Center, have been a distinctive feature of the 1970s and 1980s, and do provide for international action to agree on management objectives for areas of coastal seas in many parts of the world that are important for their fisheries and at risk from pollution. Inevitably, however, these conventions can only operate if the party sovereign states impose strict controls on their land-based activities, since the overwhelming bulk of damaging pollution entering the sea comes from the shore, and progress has been slow. It was only in 1987, for example, that the "precautionary principle" was accepted by ministers of all the riparian states as a guiding precept in the regulation of pollution of the North Sea, and only then, also, that ministers undertook to use the best available technology to curb the inputs of persistent and dangerous pollutants to those vulnerable waters.

IUCN is concerned with the sustainable use of natural resources, and the maintenance of global biodiversity and global ecological functions, as essential preconditions for an habitable planet. We are naturally unhappy about the way in which ocean resources have been used. As the draft successor volume to the World Conservation Strategy says, despite the expenditure of billions of dollars and thousands of lifetimes worldwide in order to understand and regulate human impact on the sea and its resources, "the efforts have not even approached what is needed." We need to form much clearer policies for the future, and these will have to encompass both national and international agreements and actions, since while a greater part of the ocean lies beyond national jurisdiction, all impacts upon the oceans either arise within the territory of sovereign states and their contiguous exclusive economic zones, or are carried out as a result of national exploitative activities. The international agreement and instrument is only a frame to guide the national.

I suggest that there are two particular needs as we approach the future.

The first broad requirement is to codify the objectives that we should pursue in order to ensure conservation and sustainable use of ocean and marine resources. There are five specific objectives that we could consider in this context:

A. The integrity, diversity, and functioning of marine ecosystems should be maintained.

B. All harvests of marine organisms should be held below sustainable yield, and the harvest of an individual species should not endanger stocks of other species or

the overall balance and functioning of the ecosystem. To this end, catch methods should be as selective as practicable, and the capture devices used should not be capable of continuing to fish should they break adrift from human control.

C. Inputs of sediment and chemicals, borne especially on rivers and land-based discharges, must not endanger the balance and functioning of marine ecosystems.

D. National activities in managing 200-mile exclusive economic zones must not have adverse impacts on the ecology of adjacent 200-mile EEZs belonging to other states or on the balance of oceanic systems outside the limits of national jurisdiction.

E. International cooperation should be promoted in order to ensure that ecosystems and organisms that occur within areas of ocean shared between states are managed in a compatible way.

The second broad requirement is to agree on national and international actions that transform these broad objectives into practical conservation and sustainable-use methods. These should include sound methods for the study of marine and oceanic ecosystems; for monitoring especially the status of stocks of exploited species or incidentally affected species; and for the collection, international exchange, and joint evaluation of the resulting data.

Substantial steps have already been taken in this direction, through such organizations as IOC and ICES, but these should be extended by:

A. The development of agreed methods for the management of marine resources. It is axiomatic that an ecosystem approach should be required; that inshore and offshore fisheries management should be regulated as part of one planned procedure; that the overall use patterns for large areas of ocean should be negotiated and agreed between all states concerned; and that areas which are especially vulnerable to misuse or need specially coordinated international activities, should be identified and managed on such a basis. Beyond this, the roles of the various national and regional institutions now existing, and especially the commissions of the various conventions, should be reviewed so that there is the optimal international coordination of action.

B. Action to prevent the pollution of the sea from land-based sources must have high priority, as numerous ministerial and international meetings have stated in recent decades. This will only be a practical proposition, however, if there is international exchange of information on the precise technologies that achieve industrial goals while minimizing the production of persistent and hazardous waste. Very similarly, knowledge of best practice to avoid the excessive release to the sea of nutrients from intensive agriculture and livestock husbandry need[s] to be exchanged. It is no good marine conservationists simply requiring that inputs of toxic materials to the ocean should be greatly reduced or prevented, unless it is fully understood that the consequence of such agreement is that the best available technology should be freely shared between nations, in the overall interests of the conservation of the biosphere.

C. Marine conservation areas should have, as part of their objectives, the protection of habitats that are important recruitment and breeding areas. They should be considered and established as a part of the overall strategy for the safeguarding of marine biological diversity and ecosystem processes.

I would like to expand a little on this last point. I believe that the concept of the protected area has perhaps been transferred from the terrestrial to the marine environment rather uncritically. There are real differences between terrestrial and marine ecology that need to be take[n] into account before protected areas are established and managed. Among these ecological differences are the following:

A. Very little marine primary productivity passes to the decomposers. Most marine plankton is ultimately consumed by herbivorous zooplankton or other consumers, and the benthic detritus feeders are substantially nourished by fecal material, rather than dead-plant material.

B. Turnover rates are also high in the zooplankton, and indeed, the whole dynamic of marine systems differs from that of the terrestrial.

C. Recruitment strategies for marine organisms are often quite different from those of their terrestrial counterparts. Many marine organisms, including benthic and littoral sedentary organisms, have planktonic larvae. Many fish species have eggs that are widely dispersed on ocean currents, and even species of more restricted dispersion commonly have inshore nursery grounds and offshore areas exploited by adults.

D. Marine waters mix and mingle, so that nutrients move over large areas. For example, the nutrients that well to the surface in Antarctic waters are borne from areas as far afield as the North Atlantic. The result of these movements is that it is impractical to define and bound marine protected areas in ecological terms with the same precision that terrestrial protected areas can be defined.

The establishment of boundaries for marine protected areas is likely to be of very limited ecological significance. Certainly, these boundaries will be transgressed by water

movements, with their pollutant load, and by planktonic and wide-ranging pelagic organisms. While defined areas may have ecological distinction, this will commonly result from habitat features such as depth range, temperature regimes, and the impact of terrestrial systems. The purpose in defining marine protected areas is clearly primarily to regulate human activities, but even these cannot be bounded exactly. Certain activities that may affect the integrity of an area directly, like dynamite fishing, coral mining, the dumping of wastes, the impact of fishery, the impact of tourism, or the disturbance of the habitat by modification of adjacent coastlines, can be regulated within the area. Other impacts will, however, originate well outside any marine protected area, for example, through the long-distance transfer of pollution by water or air, the input of substances in drainage from adjacent land, or the impact of human activities on adjacent marine areas. In establishing marine protected areas, it is essential to judge which key actions need to be regulated, and if these occur outside the protected area itself, then such controls need to be a part of a wider overall policy.

I would like to conclude by commenting on the usefulness of this meeting. IUCN needs the judgments it will bring to bear in evaluating which policies we should be promoting for the sustainable use of the oceans. We need them also to judge where the priorities for action lie among the numerous proposals in "Caring for the World: A Strategy for Sustainability" -- the document designed to supplement the World Conservation Strategy of 1980. I hope that the output from this meeting will be scientifically authoritative and environmentally precise, and that you will not hesitate to criticize existing policy or to propose substitutes, where it is clear that we need to do things differently, and very probably, with a greater sense or urgency than has characterized the human attitude to the oceans over past decades.

# REPORTS OF CONFERENCE WORKSHOPS

## OCEANOGRAPHIC DATA AND TRAINING NEEDS FOR THE LME APPROACH TO FISHERY MANAGEMENT

***J. Alheit, Chairman, and A. Bakun, Rapporteur[1]***

A workshop on "Oceanographic Data and Training Needs for the LME Approach to Fisheries Management" was held in conjunction with the conference. The workshop met on the morning of 5 October in the library of the Musee Oceanographique de Monaco. It was sponsored by the Program of Ocean Science and Living Resources (OSLR). OSLR itself is cosponsored by the IOC and the FAO. A list of names of workshop attendees is included at the end of this workshop report. The institutions and mailing addresses of the attendees are listed in Appendix B.

Dr. Jurgen Alheit, having been asked by the General Secretary of IOC to chair the workshop, opened the discussions. He suggested that Andrew Bakun act as rapporteur. This was accepted by the attendees without discussion. Dr. Alheit suggested the discussions be structured so as to separately treat: (1) oceanographic data needs, and (2) training needs.

### Oceanographic Data Needs

It was recognized that the workshop title may be to some degree a misnomer. We certainly don't have soundly based, widely accepted procedures for direct input of oceanographic data into fishery management activities available at this time. It was therefore agreed to direct discussion toward oceanographic data needed to support the necessary research leading toward development of such procedures. The need to forge a connection between ocean science and fisheries science was emphasized by several participants. It was suggested that establishment of an appropriate model framework would be of great aid in this respect. Of course, the development of such a model framework is itself one of the ultimate goals of the advocated interdisciplinary research.

There appeared to be a consensus that the comparative approach offered one very useful avenue into the problem area. Interregional comparisons among various classes of LMEs allow incorporation of a wide variety of available data; integrative analysis may be rather immediate and direct through a process of pattern recognition. Cited examples of useful "frameworks" for such comparative studies included the seasonal/geographical comparisons by Parrish *et al.* (1983) of habitat climatology versus reproductive habits of eastern boundary pelagic fishes, and the extension by Cury and Roy (1989) to comparison of empirical time-series relationships. Classes of LMEs amenable to such approaches might include upwelling ecosystems, semi-enclosed seas (Baltic, Mediterranean, Great Lakes, *etc.*), shallow shelf ecosystems situated along western ocean boundaries, coral reef systems, ocean shelf — deltaic — riverine interactive systems, and various other classes of comparable systems. As an alternative to structuring comparative studies in terms of physical ecosystem settings and processes, analysis of biogeographic pattern would lead to informative structures based on life history and food web patterns (*i.e.*, a comparative approach via biotic assemblages or "biomes").

[1] **La Jolla, California, 27 November 1990.**

In terms of generic data types, the participants enumerated the customary list: temperature, salinity, density, wind, nutrients, currents, sediment load, light, sea level, fishery statistics, *etc*. The need for more ecological, behavioral, and other "less customary" biological information was emphasized, as was the need for data requirements to be model-driven rather than assembled as a "shopping list." Because of the need to direct the studies toward a variety of concerns including fisheries, tourism, and pollution, certain terrestrial data such as runoff and information on various coastal characteristics (vegetation, dredging and filling, erosion, *etc*.) are often needed. The connection between estuarine and offshore processes may be a key issue. Expense of data acquisition is an important concern. Ship-of-opportunity programs may cut expenses, but coverage may be uneven. Sharing of data among countries may present problems as data perceived as having military applications may remain classified for undue periods; this may be an area where actions of international agencies could have beneficial effects.

On the subject of international data banks for LME research, it was pointed out that within the Marine Science and Technology Program of the European Economic Community (EEC), it has been decided not to create a general EEC data bank. Instead, a network among national data banks will be set up to provide access to the broad range of available data. The network system and the intercalibration of instruments will be coordinated. However, specific quality control will be a national responsibility.

Continuous plankton recorder (CPR) systems offer a means for tracking large time-/space-scale biological variability within LMEs. The burden of analysis of the samples is the main impediment to their wide use and utility. Because of this, samples may be incompletely analyzed; thus it was suggested that representative samples be saved for more complete analysis when more advanced biotechnological and/or computer imaging methods become operational. The importance of bolstering taxonomic capabilities was stressed, as was the necessity for interinstitutional and international collaboration to share the long-term analysis burden involved in generating a data base having broad utility to a variety of scientific concerns. In this connection, advantages of siting international sorting and taxonomic centers in countries where costs of analysis may be lowered were cited.

Satellite data appear to have great potential for LME research. However, difficulties of access (although improving in very recent years) remain a problem. There is presently a trend among national agencies toward "marketing" of satellite data and products in order to recover part of the cost of technological development, satellite launching, and operations. The workshop participants suggested that international agencies register strong complaints about this trend. It makes little sense that, after enormous expenditures to put the systems into operation, their data should be unavailable to support ongoing scientific research programs for lack of relatively minor specific funding within these programs. The comparative method has been identified as one of the most promising avenues for scientific progress in LME research. Therefore, the withholding of such data from use by any country or region effectively robs the taxpayers of the country having borne the heavy expense of establishing a satellite observation system of an important potential "payback" (in terms of their own LME concerns) for their investment. It was reported that a 10-year series of "Landsat" data lies essentially unutilized for LME research. The use of this data resource to support broad-scale scientific advance could be enormously enhanced by free processing and free provision of charts and maps. The practice of encoding data streams to prevent broad access is shortsighted and should be protested.

Assembling data from various ecosystems for use in applications of the comparative method may present problems. Scientists of any region who have made large personal investments of their time and expertise to assemble important data sets may be understandably reluctant to give them up for primary analysis by unspecified scientists of other regions. However, the problems of LME research are both crucial and difficult. Precedent guidelines for research progress tend to be lacking. Innovation and inspiration are at a premium. Thus, it is particularly important that an international community of scientists have access to interregional data bases in order to be able to build upon each other's ideas and insights, and to thereby participate in broad scientific advance to the benefit of all. The IMARPE/GTZ/ICLARM [Peru Institute of the Sea/German Society for Technical Cooperation/International Center for Living Aquatic Resource Management] Peruvian ecosystem project was cited as an interesting example of an innovative way to accomplish these goals. Two substantial volumes (Pauly and Tsukayama 1987; Pauly *et al.* 1989) analyze and display a large variety of time series of monthly data extending over three decades; with the second volume, ICLARM is prepared to provide all the extensive sets of basic and derived data in computer-readable form (14 floppy disks in IBM-PC compatible format). A key aspect is that the various chapters in the volumes are authored by the scientists who have assembled and provided the data. This affords them, in a single, readily identifiable reference, the opportunity to: (1) publish their own initial analysis of their data; (2) establish identification with their data sets so that follow-on users will know where to enquire about specific details, *etc*., and (3) provide a basis for proper citation of their contribution to follow-on integrative scientific analysis efforts.

In a somewhat similar area of concern, the issue of research cruises by ships of one country within the exclusive economic zone (EEZ) of another country was mentioned. It was pointed out that notification of cruise plans is often not timely enough to allow for appropriate participation by local scientists. Earlier notification would be very advantageous in terms of training opportunities and in terms of participation of local scientists in making use of the acquired data with respect to local scientific and socioeconomic issues.

## Training Needs

It was noted that needs for training in developing countries are of several types. First, there is a need to develop the scientific capabilities of research workers. This needs to be on two levels: (1) postgraduate studies, and (2) specific training for officers involved in fishery development and management. Secondly, training in effective data management is needed. Thirdly, training on the technician level is needed both in data collection and in instrumentation, where instrument failure and a lack of expertise to make appropriate repairs is a recurring problem. It was also noted that there are two aspects of training, that of students and that of teachers.

Dr. Alheit here reiterated a proposal, made earlier in the general conference discussions, for involvement of developing countries in LME research. The proposal includes: (1) a conference to be held on the subject which would demonstrate the use of modeling, identify data needs, and develop an example program for integrative LME studies in developing countries which would include "twinning" arrangements (agency to agency, institution to institution, and with potential funding sources); (2) a period within which to compile data (approximately one year); (3) regional conferences to design programs on an integrated ecosystem basis; and (4) follow-up activities to include training packages on methods to study ecosystems, and on management of national EEZs in a regional context, to include short-term (approximately two weeks) and long-term (master's level) courses.

Several participants emphasized the need for expansion of international research programs to the LMEs of the Indian Ocean. For example, it was noted that there was specific concern for expansion of OSLR projects into the Indian Ocean regions at the recent meeting of the IOC-FAO Guiding Group of Experts on OSLR (Paris, February 1990). It was announced that Kenya will consider proposing (next year) and offering to host a regional conference on the LMEs of the Indian Ocean. A special focus would be directed toward the linkage between research and training. Participants reiterated the training value of comparative studies of ecosystem function.

The development of pilot projects was a recurring theme in the discussions. These could foster exchange programs, training opportunities, and scientific collaboration between institutions in developed and developing countries. Suggested specific types of training included: (1) rational use of the EEZ; (2) use of remote sensing in coastal ecology studies; (3) CPR operation and analysis; and (4) methods for study of estuaries, particularly with respect to silt, waste disposal, and pollution.

A concern for development of adequate taxonomic capabilities for LME research was expressed. In the past, many countries had a major portion of their biological expertise within the taxonomic specialties. The situation has changed radically. There are presently few experienced taxonomic specialists and a consequent lack of university courses for an increasing number of students interested in taxonomy. It was recommended that courses and workshops in taxonomy be organized as components of regional LME symposia and other types of LME training activities. These should include modern techniques such as application of molecular and biotechnological methods. With regard to the subject of taxonomy of phytoplankton species involved in toxic or noxious blooms, it was announced that recurrent three- to four-week courses are presented at Copenhagen University, Denmark, under the IOC-FAO OSLR Program and the IOC TEMA Program. To assist in these activities, a Danish associate expert in phytoplankton will be assigned to the IOC Secretariat.

## List of Workshop References

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## APPLICATION OF THE LME APPROACH WITHIN REGIONAL SEAS AREAS

*Dr. Arthur Dahl*[2]

The UNEP-sponsored working group reviewed the correspondence between known LMEs and the existing and planned regional seas programs around the world. The regional seas action plans provided a regional intergovernmental and interagency framework for cooperation in the study and management of several LMEs appropriate in many cases to the scale of the ecosystems. The complementarity of the experience of FAO, IOC, and UNEP meant that they should work closely together in addressing the sustainable use of LMEs.

The LME concept provides an additional justification for regional action, provided that the boundaries of the system can be recognized and management plans can be developed accordingly. Since the developing regions covered by most regional seas programs lack the financial and technical capacity necessary for LME studies, efforts would be needed to build that capacity. This might include "twinning" of developed- and developing-country institutions, exchanges of scientists, and training programs in the necessary approaches and techniques. Regional task teams of local experts could provide one mechanism to bring together the variety of expertise required, and to train scientists in the LME approach. Pilot areas could be selected for special study. Comparative studies could be made of comparable systems, such as those of semi-enclosed seas or upwelling areas. Oceanwide workshops could bring together experts from developed and developing countries to consider the LME concept in their ocean basin.

The structure of the regional seas programs would also provide mechanisms for the results of LME studies to be applied in the integrated management of whole coastal systems, including pollution assessment and control, environmental impact assessment, and coastal zone planning and management.

## PROPOSED IUCN GLOBAL FISHERIES MANAGEMENT NETWORK

*Dr. Simon N. Stuart*[3]

### Introduction

The meeting took place on the morning of 5 October 1990, and was chaired by Dr. Simon N. Stuart of the IUCN Species Survival Commission (SSC). Dr. Stuart started with apologies on behalf of Dr. Gary Bernacsek, Convener of the IUCN/SSC Fisheries Management Specialist Group. Dr. Bernacsek was to have attended and chaired the meeting, but was unable to do so because of an accident.

Dr. Stuart provided a brief background on IUCN and SSC. Previous work on fisheries has been limited to: (1) field projects and policy work carried out by IUCN's Wetlands and Marine Programs; and (2) assessment of the impact of fisheries on nontarget species (cetaceans, seals, otters, marine turtles) by various specialist groups within the SSC.

In 1988, the SSC decided that a Fisheries Management Specialist Group (FMSG) should be established, since the subject represented an area of weakness within IUCN. There were also concerns that existing advisory mechanisms on fisheries management were not politically or commercially neutral, and that IUCN had a unique role in channelling high-quality, independent, technical advice to local situations in the developing world. The intention was to form an advising network under the auspices of the SSC, and working in close collaboration with the Wetlands and Marine Programs. Dr. Garry Bernacsek was asked to serve as the initial Chairman and Convener of the FMSG. Dr. Bernacsek has since developed a proposal for the functioning and objectives of the FMSG, which includes the suggestion of making the new initiative a collaboration between IUCN and the Canadian International Development Research Center (IDRC). Dr. Stuart presented a discussion paper to the meeting, which was a slightly modified version of Dr. Bernacsek's original proposal.

### Summary of the FMSG Proposal

The specific objectives in Dr. Bernacsek's proposal could be summarized as follows: (1) establish global networks of people, projects, and institutions with initial focus on artisinal fisheries;
(2) monitor the health of the world's major fisheries; (3) identify and deter use of destructive fishing methods; (4) promote the use of sound management practices for fisheries; (5) conduct training workshops; and (6) organize symposia.

The general objective of the FMSG, as suggested by Dr. Bernacsek, was "to promote sound management of the world's fisheries resources." The meeting reviewed all these objectives, as described in the next section.

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[2] Nairobi, Kenya.
[3] Monaco, 5 October 1990.

## Review of the FMSG Proposal

A number of general comments were made on the FMSG proposal as follows:

1. It was agreed that the establishment of a new IUCN/SSC network would be most beneficial. It was pointed out that such a network could become a means of sharing successes, as well as of lessons learned from failures. It was also pointed out that in a developing-country context, often very simple support is needed, such as could be provided through a network.

2. The proposal, as it was originally drafted, did not seem to provide sufficient emphasis on the key role of ecosystem management. Although it was recognized that the proposal implicitly called for ecosystem management, this should be made more explicit.

3. As well as being advisory, the network should also be catalytic, much in the way adopted by other SSC specialist groups. Specifically, the FMSG should mobilize local and national efforts in developing countries.

4. There was a general concern that the proposal focussed too much on "management," rather than on the traditional IUCN concerns of "conservation and sustainable development." Although this might just be a semantic point, it is important to stress that management should cover a broad range of disciplines, ranging from biology and ecology to sociology, rural development, and human population demography.

5. The basic principle of the draft proposal, that the initial emphasis should be on artisinal fisheries, was upheld. However, there was a strong opinion that aquaculture aspects could not be ignored, especially in the rural development context. In particular, it was felt that the following three aspects relating to aquaculture should be important for IUCN: (a) the effects of exotic species on natural species stocks and communities (through competition, predation, and spread of disease); (b) the effects of aquaculture on the recovery of natural stocks (assuming aquaculture results in reduced pressure on wild populations); and (c) the effects of aquaculture on key habitats (such as mangroves and coral reefs).

As a result of these comments, the general and specific objectives of the proposal were rewritten. The suggested general objective was: to promote the sustainable use of the world's fisheries resources through an integrated ecological approach. The specific objectives were rewritten as follows:

1. To create a global fisheries management network consisting of projects, institutions, and individuals carrying out research and development work in fisheries management, with an initial focus on artisinal fisheries and related aspects (in particular, aquaculture) from an LME perspective.

2. To monitor, from a conservation and LME perspective, the state of health of the major fisheries of the world.

3. To identify and deter the use of destructive, overexploitative, and illegal fishing methods. (No change made to this objective.)

4. To promote sustainable ecosystem management for fisheries among fishermen organizations, fishing companies, local authorities, national governments, and international bodies concerned with fisheries regulation.

5. To promote training workshops involving IUCN objectives in the sustainable use of fisheries.

6. To promote symposia on various aspects of fisheries management including those concerned with the LME concept.

The following comments were also made concerning these specific objectives. Objective No. 2 would require subdivision of the network, either regionally, or by each major fishery. It was suggested that objective No. 3 should be met in part by development of a new IUCN Policy Statement on fishing methods. Concerning objectives No's. 5 and 6, it was felt that in its initial stages, the network should promote, rather than organize, training workshops and symposia, and the FMSG should provide input into the curricula of these activities. Taking responsibility from organizing these activities could divert the network from higher priorities during the earlier stages of its development.

## Institutional Linkages

The meeting agreed that the IDRC was a particularly appropriate partner with which to develop linkages for the launching of the FMSG. Two other possible collaborators include the ICLARM, particularly from an artisinal fisheries and aquaculture perspective, and the International Council for the Exploration of the Sea, which advises the EEC on fisheries quotas. The FAO would be an obvious partner, though some concern was expressed that there might be different philosophical approaches. Among the bilateral agencies, SIDA and NORAD were suggested as collaborators, and among the nongovernmental organizations, the World Wildlife Fund and the Center for Marine Conservation.

## Conclusion

It was agreed that IUCN should continue to pursue this initiative, and those interested in guiding its further development were asked to leave their names and addresses.

# ECONOMIC INDICATORS OF BIOMASS YIELDS IN LMEs

*Dr. James M. Broadus, Co-chairman,*[4]
*and Dr. Giulio Pontecorvo, Co-chairman*[5]

## Background

During the last several years, ocean scientists and managers have gained important new insights into the processes which govern the ecology of coastal and ocean species. This has led to a new conceptual framework, called the "large marine ecosystem approach," which provides the basis for developing new strategies for marine resource management and research. These new strategies have a broad application: (1) to the ways in which countries manage their EEZs; and (2) within the context of many regionally focused conventions and action plans aimed at environmentally sound management of marine resources.

## Conference Objectives

The objective of the overall conference was to assist scientists, ocean managers, and diplomats in gaining an understanding of the relevance of the LME approach to conservation and management in their particular EEZ or region. Participants learned how they can apply the concept of LMEs within the context of their own national laws and regulations, bilateral or multilateral regional arrangements, and global treaty obligations during a period of increasing change in global environmental conditions. To achieve these aims the conference: (1) introduced the "large marine ecosystem research and management approach" to a broadly representative group of scientists, managers, administrators, and diplomats concerned with sustainable use of marine resources; (2)examined the application of the LME approach to a number of regions with particular reference to driving forces controlling sustained resource yields in relation to existing regional conventions and protocols concerned with marine pollution control and the conservation and management of marine resources; (3) finalized a series of recommendations for initiating the use of the LME approach in regions where it is most likely to assist in improving the conservation, management, and sustainable use of living marine resources; and (4) recommended appropriate monitoring of biological and physical observations pertinent to forecasting the probable effects of global change on resources at risk.

## Workshop Objectives

The one-day workshop, held as a complementary follow-on to the larger LME conference, achieved the following objectives: (1) evaluated the utility of using catch, catch per unit of effort, fishing power, and other economic indicators for monitoring **long-term** changes in biomass yields for LMEs; (2) examined the availability and quality of economic indices relevant to **short-term** management of living marine resources in LMEs; (3) considered alternative systems for improving exchanges of economic indices pertinent to biomass yields of LMEs; and (4) prepared advice for consideration by marine resource managers on protocols for improvements to present systems in use for the collection and dissemination of economic indices relative to monitoring biomass yields in LMEs.

## Workshop Report

The workshop reached agreement on the following conclusions:

1. LMEs contain many types of living resources which interact in complex ways over time. LMEs are themselves natural resources.

2. The information required for effective management of LMEs depends on the objectives of management.

3. A proper management objective for LMEs is conservation to maximize their contribution to human well-being over time. (There was consensus on conservation rather than strict preservation. Some discussants favored including some mention of "sustainable" use and explicit reference to biological diversity.)

[4] **Woods Hole, Massachusetts.**
[5] **New York, New York.**

4. Economic and biological data associated with fisheries can be a valuable source of information on LMEs, but they can be misleading. Much better understanding is needed of the relationship between fisheries and LME biomass dynamics. Further efforts should be made to relate available national and international fishery statistics to LMEs.

5. Exploitation of ocean resources requires other inputs, such as capital and labor. Abundance and cost of these other inputs also affects the optimal intensity and allocation of exploitation. Account must be taken of all values, not just market values. Information is needed on natural/physical interactions, effects, and tradeoffs. We may not need complete detail; rough answers may be enough, since research and management are costly themselves.

6. The cost of management, including enforcement cost, is important in determining the optimal management organization. Depending on relative costs and benefits, different levels of management effort may be appropriate for different resources, activities, or areas within LMEs. There is no reason to think that a single, comprehensive management organization is best for LMEs. Indeed, organizational diseconomies of size and scope might well hinder the effectiveness of such a monolithic authority.

7. Principal issue raised by LME approach in terms of management is **scale**. As we try to extend the scope of management, the cost of management increases. The optimal scope of management is likely to be less than universal, and it may be less than the entire LME. We may use a subset of a full system as a model of the larger system.

8. The group agreed that cost-effective case studies could be useful in determining how to combine economic and ecological information in managing LMEs. The North American participants cited the U.S. Northeast Continental Shelf Ecosystem and its subsystem, Georges Bank, as promising case studies.

9. An interesting research issue is what information is needed to determine the optimal size and scope of management within an LME. How does this information differ from that needed to manage an LME?

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Dr. Lee Anderson
Dr. Carlos Bas
Dr. Barry Gold
Mrs. Nicole King-Volcy
Mr. Kelton R. McKinley
Ing. A. Robles
Dr. Jon Sutinen
Dr. John P. Wise

# REPORTS OF INFORMAL DISCUSSION GROUPS ON CANDIDATE LMEs

Conference participants explored issues relating to the designation of geographic regions of the globe as candidate LMEs. Three concurrent discussion sessions were held on 4 October dealing with: (1) enclosed and semi-enclosed seas, (2) Atlantic Rim regions, and (3) Pacific Rim regions. Reports from all three groups recommended that the Conference give a high priority to the designation of global LMEs, based on consensus among regional experts. The reports of the discussion groups were considered during the concluding plenary session. Based on the reports, the conference participants agreed that high priority be given to the "...production of a map of the distribution of LMEs. Such a map would be sent to regional experts for review and comment." The complete list of conference recommendations is given in the "Recommendations" section of this volume.

## ENCLOSED AND SEMI-ENCLOSED LMEs

***Dr. Francois Doumenge, Discussion Leader[6]***

The working group on enclosed and semi-enclosed seas LMEs did not include discussions of completely closed fresh- or salt-water systems operating like lakes.

The consensus of the working group was that semi-enclosed seas have the following characteristics:

1. Water exchanges play an essential role, both in the world's oceans and within the same basin, between one division and another. The character of the exchange depends on the geomorphology of the straits and on the

[6] Monaco, 6 October 1990.

pressures initiating the flux of water flow in both directions.

2. Semi-enclosed seas are subject to pressures from continental phenomena responsible for weather patterns and for supplying fresh water and sediments.

3. Human activity can increase or reduce continental pressures on the semi-enclosed seas.

4. Semi-enclosed seas are characterized by young ecosystems which remain unstable and subject to numerous stresses.

5. In general, semi-enclosed seas consist of a mosaic of small units which evolved through definite stages in establishing their biological diversity.

6. Their generally smaller scale is a dominant characteristic relative to the larger oceanic ecosystems. It is important, therefore, to apply the concept of LMEs to subunits within which production phenomena are diversified through mechanisms that are unique to them and remain poorly quantified.

## ATLANTIC RIM

### *Dr. Steven Bolt, Discussion Leader*[7]

The initial discussion attempted to reach agreement as to a definition of LMEs. It soon became apparent that there was confusion as to how to decide on definitions and boundaries. It was decided that we would consider the Atlantic for potential LMEs with each delegate proposing areas. The concept would then be reappraised in light of a list of sites put forward by the participants. A list of 20 LME sites was proposed that encompassed the Atlantic rim from the Arctic clockwise, from the Norwegian Sea Ecosystem to the Laboradore Shelf Ecosystem.

All of the delegates agreed that the concept of using an holistic ecosystem approach to fisheries/conservation/marine management is an important advance from single-species economic management. However, it was obvious from the proposed list of LMEs that there was a substantial difference of approach by the delegates as to what constitutes an LME. It was, therefore, recommended that there is a need for a set of criteria to be created to allow countries a better understanding as to what actually constitutes an LME.

## PACIFIC RIM

### *Dr. Joseph Morgan, Discussion Leader*[8]

The discussants reviewed the designations made earlier of LMEs around the Pacific Rim. Although no consensus was reached, the group agreed that the initial designations published in the 1989 volume by the American Association for the Advancement of Science represented the basis for further consideration by regional experts, as recommended by the full plenary.

The group recommended that further consideration be given to LMEs in which the predominant issues are not limited to fisheries assessment and management, but also include considerations of entire marine communities in relation to the long-term sustainability of the entire ecosystem. The group referred to the comprehensive presentations of Dr. Laurence Mee on the Gulf of California Ecosystem and Dr. Graeme Kelleher on the holistic management of the entire Great Barrier Reef Ecosystem.

## Convener's Note

The reports of the Atlantic Rim and Pacific Rim Discussion Groups were considered at the concluding plenary session of the conference. Based on the deliberations, it was agreed that the list provided by the group of 20 candidate LMEs for the Atlantic Rim, and the published report on the Pacific Rim LMEs and the Atlantic Rim LMEs[9], were useful for discussion purposes. No consensus was reached on the candidate systems. The recommendation by the conference to give highest priority to the designations of LMEs on a global basis will provide the opportunity to reexamine the candidate LMEs based on recommendations of regional experts. To the extent possible, the participants in the Atlantic Rim and Pacific Rim Discussion Groups will be included among the regional experts contacted.

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[7] **Peterborough, United Kingdom.**

[8] **Honolulu, Hawaii**

[9] **Morgan, J. 1989. .Large marine ecosystems in the Pacific Ocean. *In*: Sherman, K.; Alexander, L.M., eds. Biomass yields and geography of large marine ecosystems. *AAAS Sel. Symp.* 111: 377-394. Boulder, CO: Westview Press, Inc.**

**Prescott, J.R.V. 1989. The political division of large marine ecosystems in the Atlantic Ocean and some associated seas. *In*: Sherman, K.; Alexander, L.M., eds. Biomass yields and geography of large marine ecosystems. *AAAS Sel. Symp.* 111: 395-442. Boulder, CO: Westview Press, Inc.**

# APPENDIX A
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France
Germany
Greece
India
Italy
Kenya
Mexico
Monaco
Morocco
The Netherlands
Nigeria
Norway
Peoples Republic of China
Phillipines
Romania
Scotland, United Kingdom
Senegal
Seychelles
Solomon Islands
South Africa
Spain
Switzerland
Thailand
Turkey
United States of America
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# APPENDIX C
# CONFERENCE PROGRAM

## PLENARY

Welcoming Address of the Host,
*by H.S.H. The Prince Rainier III, Sovereign Prince of Monaco*

Welcome by the Host Institution
*by Francois Doumenge, Director of Musee Oceanographique du Monaco*

Marine Conservation and Development for the 1990s
*by Martin Holdgate, Director General, The World Conservation Union*

Keynote Address
*By John Knauss, Under Secretary for Oceans and Atmosphere of the U.S. Department of Commerce*

Introduction to the Conference on Behalf of the Organizers
*by Thomas Laughlin*

Introduction to LMEs as Entities for Management: An Ecological Perspective
*by Kenneth Sherman*

The LME Approach to Regional Seas Action Plans and Conventions: A Geographic Perspective
*by Arthur Dahl*

Legal Regimes for Management of LMEs and Their Component Resources
*by Martin Belsky*

Ecological Theory and Alternate Stable States of LMEs
*by John Beddington*

## LME THEORY AND APPLICATIONS

Purpose and Organization of LME Conference from a Scientific Perspective
*by Gotthilf Hempel*

Biodynamic Theory and LMEs
*by Brian Rothschild*

Application of LME Management for Pollution-Driven Systems
*by Alasdair McIntyre*

Application of International Global Change Research Programs to Long-term LME Management
*by Michael Reeve*

The Utility of LME Concept to Ocean Management
*by Robert Knecht*

Models for Forecasting Biomass Yields in LMEs
*by Simon Levin*

## REGIONAL CASE STUDIES

The LME Strategy for Resources at Risk within the EEZ of the United States
*by Virginia Tippie and Charles Ehler*

The CCAMLR as a Model for Ecosystem Management
*by Tucker Scully*

The Baltic Sea as a Pollution-driven LME
*by Gunnar Kullenberg*

A Regional Approach to Research and Management of Living Marine Resources in the Northern California Current Ecosystem
*by Daniel Bottom*

Long-term Variability in the Food Chains, Biomass Yields, and Oceanography of the Bay of Bengal Ecosystem
*by Sree Dwivedi*

The North Sea Ecosystem from a Fisheries Yield Perspective
*by Niels Daan*

Effects of Physical and Biological Changes on the Biomass Yield of the Humboldt Current Ecosystem
*by Jurgen Alheit and Patricio Bernal*

Food Chains, Physical Dynamics, Perturbations, and Biomass Yields of the Sea of Okhotsk Ecosystem
*by V. V. Kusnetsov, V. P. Shuntov, and L. A. Borets*

The Effects of Long-term Physical and Biological Perturbations of the Contemporary Biomass Yields of the Yellow Sea Ecosystem
*by Qisheng Tang*

Effects of Climate Changes on the Biomass Yield of the Barents Sea, Norwegian Sea, and West Greenland Sea LMEs
*by Johan Blindheim and H. R. Skjoldal*

Physical and Biological Parameters Influencing the Biomass Yields of the Benguela, California Current, and Patagonian Shelf Ecosystems
*by Andrew Bakun*

Faeroe Plateau Ecosystem: Biological Patterns
*by K. Vagn Hansen*

The Gulf of California Ecosystem: Patterns and Processes
*by Laurence Mee*

Long-term Variability in the Food Chains, Biomass Yields, and Oceanography of the Canary Current Ecosystem *by Carlos Bas*

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## TECHNOLOGY APPLICATIONS

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## REPORTS AND RECOMMENDATIONS OF DISCUSSION GROUPS TO PLENARY

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## WORKSHOPS ORGANIZED BY CONVENING AND SPONSORING ORGANIZATIONS

Establishment of an LME Fisheries Management Specialist Group within IUCN,
*IUCN Species Survival Commission*

Application of the LME Approach within Regional Seas Areas
*UNEP Regional Seas Program*

Oceanographic Data and Training Needs for the LME Approach to Fisheries Management
*IOC/FAO*

The Legal Regime for the Management of Living Resources of an LME
*FAO*

Economic Indicators of Biomass Yields in LMEs
*NOAA-NMFS/IUCN*

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77. **Shell Disease among Red Crabs Inhabiting Submarine Canyons of the New York Bight.** By Randall R. Young. December 1989. iii+9 p., 18 figs., 5 tables. NTIS Access. No. PB90-194762/AS.

78. **Seasonal Distribution Patterns of Commercial Landings of 45 Species off the Northeastern United States during 1977-88.** By Sukwoo Chang. October 1990. v+130 p., 246 figs. NTIS Access. No. PB91-160846.

79. **Contaminants in Sediment and Fish Tissue from Estuarine and Coastal Sites of the Northeastern United States: Data Summary for the Baseline Phase of the National Status and Trends Program Benthic Surveillance Project, 1984-1986.** By Vincent S. Zdanowicz and Donald F. Gadbois. December 1990. x + 138p., 67 figs., 21 tables. NTIS Access. No. PB92-147453/AS.

80. **Distribution of Sexually Immature Components of 10 Northwest Atlantic Groundfish Species Based on Northeast Fisheries Center Bottom Trawl Surveys, 1968-86.** By Susan E. Wigley and Wendy L. Gabriel. January 1991. iv + 17 p., 23 figs., 3 tables. NTIS Access. No. PB92-101617.

81. **Status of the Fishery Resources Off the Northeastern United States for 1990.** By Conservation and Utilization Division, Northeast Fisheries Center. January 1991. iv + 130 p., 50 figs., 82 tables. NTIS Access. No. PB91-213785.

82. **Response of the Habitat and Biota of the Inner New York Bight to Abatement of Sewage Sludge Dumping: Third Annual Progress Report--1989**. By Anne L. Studholme, Merton C. Ingham, and Anthony Pacheco, eds. February 1991. vi + 57 p., 74 figs., 20 tables, 1 app. NTIS Access. No. PB91-208199.

83. **Organic Contaminants in Hepatic Tissues of Lobster and Flounder at the New York Bight "12-Mile" Sewage Sludge Dumpsite: 1987-88**. By A.F.J. Draxler, Paul Hauge, and Ashok D. Deshpande. July 1991. iii + 10 p., 3 figs., 8 tables. NTIS Acccss. No. PB93-114635/AS.

84. **Trophodynamics of Select Demersal Fishes in the New York Bight**. By Frank W. Steimle and Russell Terranova. July 1991. iv + 11 p., 1 fig., 16 tables. NTIS Access. No. PB92-157999/AS.

85. **Factors Influencing Spring Distribution, Availability, and Recreational Catch of Atlantic Mackerel (*Scomber scombrus*) in the Middle Atlantic and Southern New England Regions**. By William J. Overholtz, Reed S. Armstrong, David G. Mountain, and Mark Terceiro. August 1991. iii + 13 p., 9 figs., 3 tables. NTIS Access. No. PB92-160209.

86. **Status of Fishery Resources off the Northeastern United States for 1991**. By Conservation & Utilization Division, Northeast Fisheries Science Center. September 1991. iii + 132 p., 55 figs., 72 tables. NTIS Access. No. PB92-113786.

87. **Evidence of Structural Change in Preferences for Seafood**. By Steven F. Edwards. January 1992. iii + 12 p., 3 figs., 1 table. NTIS Access. No. PB93-114650/AS.

88. **Synopsis of Principal Diseases of the Blue Crab, *Callinectes sapidus***. By Gretchen A. Messick and Carl J. Sindermann. January 1992. iii + 24 p., 13 figs., 2 tables. NTIS Access. No. PB92-219757.

89. **Proceedings of the NEFC/ASMFC Summer Flounder, *Paralichthys dentatus*, Aging Workshop, 11-13 June 1990, Northeast Fisheries Center, Woods Hole, Mass.** By Frank P. Almeida, Raoul E. Castaneda, Roman Jesien, Richard E. Greenfield, and John M. Burnett. January 1992. iii + 7 p., 8 figs., 2 tables. NTIS Access. No. PB93-114643/AS.

90. **Fish and Megainvertebrates Collected in the New York Bight Apex during the 12-Mile Dumpsite Recovery Study, July 1986-September 1989.** By Stuart J. Wilk, Robert A. Pikanowski, Anthony L. Pacheco, Donald G. McMillan, Beth A. Phelan, and Linda L. Stehlik. October 1992. iv + 78p. 9 figs., 2 tables, 2 app.